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Procedia Computer Science 100 (2016) 894 – 899

Procedia Computer Science

Conference on ENTERprise Information Systems / International Conference on Project MANagement / Conference on Health and Social Care Information Systems and Technologies, CENTERIS / ProjMAN / HCist 2016, October 5-7, 2016

Pedagogical strategies for the integration of Augmented Reality in ICT teaching and learning processes

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Abstract

The technologies that are being gradually introduced in educational contexts enable students to diversify the ways for knowledge building. However, the exploitation of new technologies in the classroom is always a challenge for all interveners in the educational process. The arrival of a new technology, as is the case of augmented reality devices, captures the teachers' attention. It creates the expectation that its uses may provide students with new ways to interact, new possibilities of collaboration between students and between students and teachers and potentially an increase in the motivation for learning. In this context we may find some examples of this technological introduction in learning scenarios. But the referred expectations and the most suitable strategies for its use need to be validated and new ones to be explored. This is the purpose of this research. This project is being carried with sixty-two students from the 8th grade in the Information and Communication Technologies subject. It follows an action-research methodology and for the implementation of the several research cycles that follows this methodology different prototypes for students to use in classroom were created and are being evaluated. The prototypes range from simple technological integrations to more complex ones with the introduction of an augmented reality system. The study aims to identify and explore the pedagogical strategies by evaluating them in real teaching and learning scenarios, particularly in terms of competences developed and student motivation levels, as well as on the ways of integrating different devices for augmented reality. The preliminary results show that students understand the support and contents provided by the prototypes and feel higher motivation when using it in the assignments'.

Peer-review under responsibility of the organizing committee of CENTERIS 2016

Keywords: Information and Communication Technologies; Educational Technologies; Augmented Reality; Digital skills; Traching/Learning strategies; Google Cardbords.

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Peer-review under responsibility of the organizing committee of CENTERIS 2016
doi:10.1016/j.procs.2016.09.240

1. Introduction

ICT assumes an important role in all areas of our society and the school as a place of inclusion should be able to satisfy the needs and overcome the difficulties students have, preparing them for the constant changes that technologies provide. As Rêgo[1] states "is desirable that the school's objectives are in line with the evolution and necessities of this demanding society". The same author indicates that there is a lag between the competences acquired by the students and necessary competences to the society. The inclusion of technology and new technologies in the educational context opens new possibilities for the teacher to innovate in their teaching methods and creates possible conditions for the student to overcome learning difficulties and strengthen its competences.

According to Sobral and Menezes[2], following the results of a case study about the motivation of students with and without the use of Information and Communication Technologies in the classroom, students should be encouraged to use tools that promote new experiences and therefore the ICT subject should be focused on the practical uses of existing resources in an experimental way, promoting the interaction and coordination with other subjects of the curriculum. It should also encourage students to develop their collaboration, sharing, creativity and autonomy skills. The teacher needs to adapt the program contents to its students' interests without neglecting their prior experience in the use of technologies within and outside the classroom. In ICT classrooms new technologies have the potential to modify the educational reality, motivating students to an unusual experimentation capacity. Thus, it is a challenge for teachers throughout the school year to create strategies that rely on the use of technology to encourage and motivate students to build their learning and the valorisation of educational resources.

After presenting some projects focused on the use of augmented reality systems in educational contexts, this paper presents the goals of this project, the two research cycles that were already implemented and the results and conclusions gathered so far concerning the evaluation of the use of the prototypes by students. Finally it presents an overview of the remaining prototypes that will be implemented.

2. Augmented Reality

According to Van Krevelen and Poelman[3] an Augmented Reality (AR) system combines the alignment of real objects with virtual ones in a real environment and is implemented interactively in real time in three dimensions. Azuma[4] also indicates that the AR is a system composed of three principles: the combination of virtual elements with a real environment; a real time interactive technology and data processing and the use of three dimensions. According to Lutz Becker, Stricker and Bockholt[5] AR is a form of interaction between man and machine where digital information is displayed in the users' vision field. Therefore AR can be summarized as a combination of real with virtual elements that stimulate interactions by the users supported by technological devices.

The introduction of technological innovations derives from and promotes a stimulation of the human creativity and imagination. As stated by Morais[6], the use of AR technologies may foster ideas that appear ahead of technological development. In the current context, AR technologies have been introduced in several areas of work and leisure, including the strong and promising area of AR mobile and gaming applications.

In this context, the educational area has already started introducing AR technologies. According to Veloso[7] the challenge is focused on achieving and developing the appropriate experience to support learning experiences. It means that the challenge is not only the introduction of technology in the classroom but mostly on how to use it to enhance student learning. Shelton and Hedley[8], in a study with more than thirty higher education students of a geography subject at the University of Washington on the theme "the relationship between the earth and the sun" concluded that there is big potential in using AR display interfaces in education. The results show that after carrying out the exercises students made less mistakes and a significant improvement in understanding the subject contents was confirmed. The authors concluded that the AR introduction in the classroom improved the overall quality of the teaching and learning experience.

According to Leitão[9] different ways for interacting with AR solutions have been explored in educational scenarios to provide students with access to real time information.

The following table is a summary of the most relevant projects that use AR in education context.

Table 1: Related projects with the use of AR in educational context

Project	Identification	Source	Research Group	University/School	Students
1	iCSI	http://education.mit.edu/portfolio_page/icsi/	Judy Perry	MIT	Middle school students
2	Writing Numbers 1 through 9	http://technologyinearlychildhood.com/	Karen Nelson	-	Pre-K classroom
3	365daysofglass	http://365daysofglass.com	Margaret Powers	-	PreK-2nd
4	Augmented Reality Magic Book: Solar System	http://www.arined.org/?p=964	Nedim Slijepcevic	-	K-12

Project	Goals	Description	Tech./App./Soft.
1	Engage young people in science content	Development of location-based games, tools and curriculum to help informal educators engage middle school students in science investigation.	iOS, Android, Web browser
2	Understand the numbers	Teaching numbers formation on the iPAD with AR	iPAD, Aurasma app
3	Research teaching practices	Collection of successful practices and resources for educators interested in AR (glasses)	Mobile Device
4	Explore the use of AR in learning and education	Creation a book containing essential factual knowledge about the planets of the Solar system	Mobile device, iOS, Android, desktop applications

The authors concluded that the use of AR systems in the referred projects promotes the success of the learning process, increasing concentration and essentially motivating students to overcome their learning difficulties. This technological diversity that has been emerging in educational contexts has allowed students new opportunities to acquire knowledge and improve their school performance. However, the experiences are still in its early stages and, therefore, a great potential and relevance for further studies is perceived.

3. Research purpose

This project has three main goals:

- To define a set of *guidelines* (best practices) for the integration of AR systems in teaching and learning contexts;
- To evaluate if the introduction of AR technologies in the learning process carries significant improvements in the motivation and competences acquisitions of students;
- To identify, explore and evaluate different strategies for the integration of AR devices and features in the teaching and learning process of ICT subjects.

This research project uses a sample of sixty-two students from three 8th grade classes of the Agrupamento de Escolas D. Pedro IV, Vila do Conde. These students do not have prior experience with AR systems and most of them not even know about this type of technology.

This project follows an Action Research methodology and therefore includes several research cycles focused on the development and evaluation of different AR based prototypes and related teaching strategies for its integration in the ICT curriculum.

According to Coutinho[10] Action Research is increasingly used in educational contexts because it promotes the discovery of new methods and learning strategies and essentially has the potential to contribute for the motivation of students so that they can, with their work, achieve new attitudes and values in society. The adoption of this methodology is based on the fact that it is intended to make changes in the teaching and learning process, and identify effective strategies for this process. According to Coutinho et al.[11] a research must contain in itself an intention to change. The Action Research methodology is based on a model in cyclical spiral and according to McNiff and Whitehead[12] this model should be a systematic and structured process. All prototypes introduced in several cycles of this study follow those four stages so that the next cycle continues in a reflective way of the work previously done. The process itself is as relevant as the results so all situations in must involve constant "surveillance" posture throughout the research process. In accordance with the ideas described, this research is structured in four cycles; each cycle comprises the introduction of a prototype and the evaluation of its uses by students. For a better understanding of the work, these four prototypes are described below.

3.1 First and second research cycle

In the first research cycle considering that students had no idea on how augmented reality systems worked, to ease the understanding about its principles the first prototype was built with the goal of creating a parallelism between transparencies (acetate) over printed assignments with the function of a device with an AR system that integrates the real object with the virtual in a real environment. The transparencies contained printed solutions and when overlaid on an assignment paper with questions revealed the solution for the assignment, in an analogue “version” of an AR system. First, the students tried to solve the assignment by themselves, then the transparencies strips with the solutions were given to students. Each strip contained a solution to a question (Fig. 1). In other for students to be able to identify the strip that corresponded to each specific question a puzzle with different software logos was used. The image printed in the transparency strip (Fig.2 - a) would have to fit in the corresponding pair of the paper assignment (Fig.2 - b), thus creating an interactive process for the visualization of solutions. The correct overlap of both images (Fig.2 - c) meant that the solution was placed in the right place, i.e. in the right question.

Fig. 1. A transparency strip overlapping the paper assignment

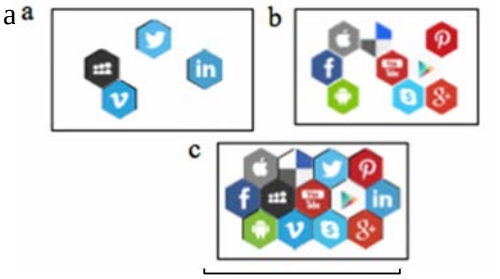


Fig. 2. (a) An enigma on the transparency strip; (b) Enigma on the paper assignment; (c) Overlaid images

Despite the fact that this prototype was prepared with paper and transparencies the main objective was to prepare students to work with AR systems.

The second research cycle was designed to include a prototype that reflected on the observation and considerations gathered in the evaluation of the prototype of the first cycle.

Considering that students expressed that this type of prototype was also suitable for other subjects, the second prototype consisted on the resolution of an assignment that integrated contents of ICT and Natural Sciences subjects. It was focused on (information) search techniques and materials flow in ecosystems, respectively. This prototype introduced the use of mobile devices. Students had to install an application to scan for qr-codes. To solve the assignment students used a system that scanned qr-codes, which linked to multimedia content related with each question of the paper assignment (Fig. 3). Despite not knowing or having prior experience about qr-codes, students were comfortable with it. Actually, after the experience they started to look for other qr-codes in several text books.

a b

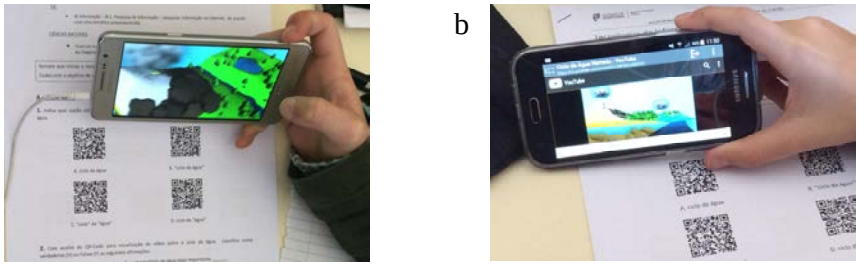
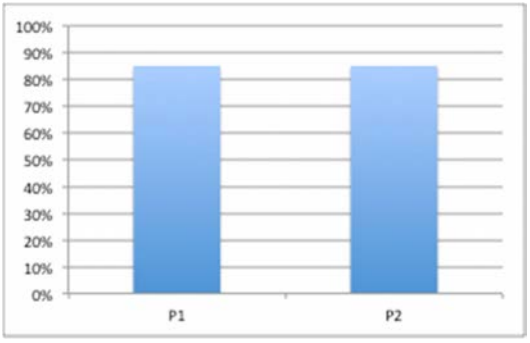


Fig. 3. (a) Graphic animation of the water cycle; (b) Watching a specific video on YouTube

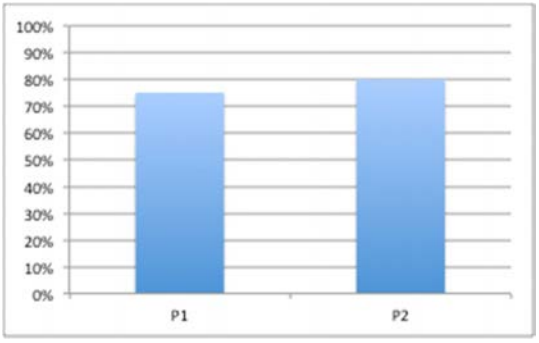
The incorporation of this prototype was designed to enable students to obtain information instantly on their mobile devices while completing a work assignment. The students, with the qr-codes, were able to access and watch in the mobile device: videos, images and information, information that students were encouraged to use in the search for solutions for the assignment.

3.1. What has been achieved and its relevance

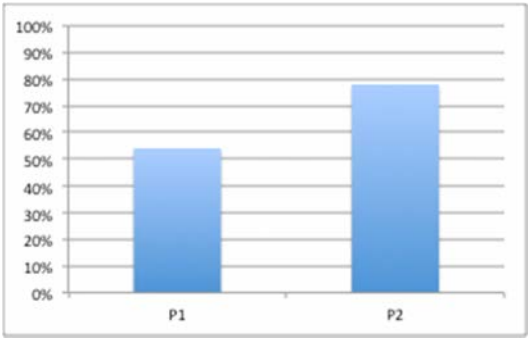
After the completion of the exercise students were invited to answer a questionnaire about their experience. Some significant results of the questionnaire can be seen in the following graphs.



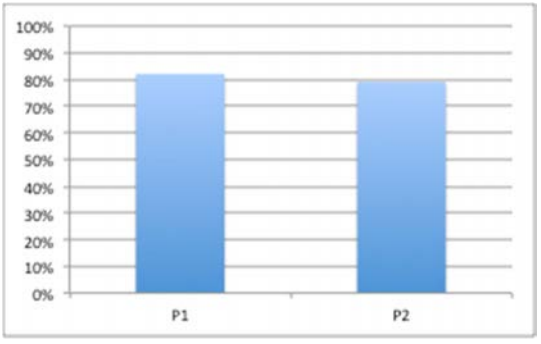
Graph. 1 Students motivation using prototypes



Graph. 2 Understanding the subject contents using prototypes



Graph. 3 Students opinion on the suitability of the prototype to be used in other subjects



Graph. 4 Concentration of the students using prototypes

The analysis of the students opinions expressed in the questionnaires revealed that the use of the prototypes added an extra motivation for students when solving assignments (above 85% of students using any of the two prototypes – see Graph 1). When asked if the use of the prototypes helped them understand and consolidate the contents, students

clearly said yes, with values between 75% (Prototype 1 (P1)) and 80% (Prototype 2 (P2)) (see Graph 2). It is also important to highlight a small improvement from prototype 1 to prototype 2 (the one with the mobile device).

In Graph 3 it is possible to verify that the introduction of mobile devices in prototype 2 increased the perception of students on the usefulness of such a system in other subjects. When asked about the impact of the prototypes in the concentration (Graph 4), 82% from P1 state that they kept their levels of concentration. P1 got a slightly lower number, but still high. Based on this, we may conclude that adding more technology has a slight negative impact on the concentration of students but a big impact on the motivation.

4. Results and Future Work (following cycles)

From this preliminary data analysis along with the researcher observation it was conclude that the students were focused on the assignment completion and the prototype helped them to better understand the subject contents. Students expressed an extra motivation using the prototype and found the prototype suitable for solving exercises of other subjects. With this research various concepts that were unknown for students were assimilated and that may have influenced on their attitudes towards school materials, as reflected on the motivation to read through the qr-codes available in other school manuals of different subjects – until this point they were rendered useless by students.

This research project is entering a second stage, the following cycles include the introduction of the prototypes to assess and draw more precise conclusions about the use of AR in educational contexts. The next steps in the project include the execution of the two following cycles. The effective use of mobile devices with AR system starts in the third cycle with the introduction of an assignment in digital format, in which the student, for its completion will have to use a mobile device with an AR application. In the last cycle we plan to introduce a simulation of the use of AR glasses, allowing to test mobility scenarios. For this, Google Cardboards (Fig. 4) will be used.

Fig. 4. Google Cardboard

The work continues with deeper analysis on the gathered data and the completion of the following cycles. A preliminary analysis of the results shows a promising field of research. The next stage in this research includes the promotion of the use of prototypes three and four with deeper technological integration. This work includes not only the experiences with students but also sessions to gather the teachers opinions to verify their perception on the added value that augmented reality can have in the teaching and learning process.

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